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FLAVONOID CHEMISTRY OF THE CYPERACEAE: A PRELIMINARY SURVEY

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ABSTRACT

The flavonoid composition has been studied in 161 specimens representing all the tribes of the family Cyperaceae and the large majority of the genera. The largest genera were represented by a number of species originating from different continents. The report deals with the compounds that are deep purple in transmitted UV light. A trend is observed in the occurence of these compounds, showing them to be, on the whole, more numerous in members of tribes where bisexual flowers occur. The majority of the compounds studied were found to be C-glycosides. One of these seems to be unique to fourteen genera of the Rhynchosporeae. In the tribes Scirpeae and Cariceae O-glycosides also occur. In these chemical characters the tribe showing the most homogeneous pattern in the family is the Cariceae.

CONTENTS

INTRODUCTION

The difficulties met with in the taxonomic treatment of any part of the family Cyperaceae have been amply stressed during this symposium. Indeed, the purpose of the symposium is to put together different views in an attempt to obtain better results. For this reason it may be in place here to focus your attention on certain aspects of the chemical composition of the family Cyperaceae.

In this respect, the group of compounds technically easiest to study are, possibly, the flavonoids. Few data about the flavonoid chemistry of the Cyperaceae have been published (Hegnauer 1963). However, quite recently the family has again attracted attention. Thus Bate-Smith (1968) has studied certain compounds and their distribution within the family in fourteen species of Cyperaceae. Clifford and Harborne (1969) were unable to find any anthocyanins in eighteen species studied. In another connexion, when emphasizing the need for more extensive surveys when chemical data are collected for taxonomic purposes, Harborne (1967:306) pointed out that in flavonoid studies dried herbarium specimens can be used (Chichester & Nakayama 1965).

The aim of the present study has been to survey the flavonoid compounds of the Cyperaceae on a broader basis and to find out to what degree flavonoid chemistry might be of help in solving the taxonomic problems encountered in the family.

MATERIAL AND METHODS

The material used consisted partly of living specimens collected in the field in Finland and in the surroundings of Austin, Texas, partly of small specimens which I was permitted to take from herbarium sheets in the collections of the Smithsonian Institution (US), Washington, D.C. The vouchers of the former specimens are deposited in Helsinki (H). The sheets in US from which the material was removed were annotated correspondingly. The specimens are listed in Table 1. The material of the only arborescent member of the family, *Microdracoides squamosus,* was obtained from Berlin (B). The species are treated in tribes according to Schultze-Motel (1966). The names used are, as a rule, those under which the specimens are arranged in US; however, the determinations were checked as far as possible when the samples were selected, and frequently they were taken from sheets determined by a well-known specialist. In many cases, the generic names used are today frequently believed to represent only small segregates from well-known genera and are reduced to synonyms by many scientists. The only reason for this usage is to emphasize their once assumed distinctness. In Table 1 specimens for which a variety of analytical data are available are in italics.

The laboratory work was carried out in winter 1967—68 at the Department of Botany, University of Texas, at Austin. The flavonoids were extracted from the material studied, using 50% methanol in water. At least one chromatogram of every specimen was prepared. For this, a piece weighing 0.05—0.1 g was used. In the case of *Carpha alpina* this was possibly too much, because in the chromatogram a single large (30×10 cm) deep purple spot resulted. From the material collected in the field for the purpose twenty chromatograms were prepared. For further analytical purposes there was no material available of any member of the tribe Lagenocarpeae. In

preparing the chromatograms the solvents used were: a) a mixture of tertiary butanol, acetic acid and water, 3:1:1 (TBA); and 15% acetic acid (HOAc). For isolation of the compounds ten of the chromatograms were used. The compounds were routinely tested for hydrolysis with β-glucosidase and with 6% hydrochloric acid. The UV spectra were recorded with a Beckman DB-G spectrophotometer equipped with Sargent model SRL recorder. More details of the procedure have been published by Mabry, Markham and Thomas (1970).

In the chromatograms the distribution pattern of the compounds, spots, and their appearance in transmitted UV light was studied. The position of the spots is recorded, using R_f values. In the following the R_f values are always given in the order TBA: HOAc. They are presented separately for each tribe in the scatter diagrams (Figs. 1—5). The terms used to describe the appearance of the spots are those adopted by Mabry et al. (1970). In this paper only those compounds appearing deep purple in UV light are dealt with (see Mabry et al. 1970:13); these form, perhaps, the majority of all the spots recorded. The colour changes were studied after fuming the spots with ammonia.

RESULTS

Average number of compounds

The number of compounds that are deep purple in colour is given for each species in Table 1. This number is by no means to be taken as an absolute final result; it rather indicates the trend, whether numerous or only very few compounds are to be found in the species in question. For example, two samples of *Scleria ciliata* were studied, both collected in Texas in autumn 1967. In one of them only five compounds were recorded (no. 21), these five spots being the ones in which the concentration of the compound was high enough to warrant a spectrophotometric study. However, another sample (no. 32), which differed in size from the previous one, resulted in a better separation of the compounds on the paper. When, in addition, even the slightest tints on the paper were taken into account, the number of deep purple compounds amounted to as much as thirteen. This example represents an extreme case. However, some differences are also to be found in other cases in which two samples were studied (see *Dulichium, Cyperus rotundus, Carex echinata, C. nigra* and *Eleocharis montevidensis*).

Another source of error must also be pointed out. When one of the spots in the chromatograms of *Carex rostrata* (R_f values 0.26; 0.19) was closely examined, it was found to consist of not less than three separate compounds. The spectra of these three compounds, as well as the R_f values, showed only small differences, suggesting that there were only some minor differences in their structure. Thus at this stage, it is impossible to state exactly the total number of deep purple compounds observed in this study.

However, the total number of those for which spectral data are available is estimated to be about 80, possibly even more.

As Table 1 shows, a great variation was recorded in the number of compounds within each tribe. However, certain trends in their occurrence can be pointed out.

Thus, especially large numbers of compounds were found in the tribes Scirpeae (*Crosslandia* 11, *Scirpus* 10), Rhynchosporeae (*Cladium* 10, *Tetraria* 8), and Dulichieae (*Dulichium* 9). In *Scleria*, although the flowers are unisexual, the number may amount, exceptionally, to thirteen, as was pointed out above. However, in the first-named tribes small numbers were recorded as well. For example, in *Ficinia* and *Websteria* (Scirpeae) only one compound was detected, and two in the genera *Arthrostylis* and *Pleurostachys* (Rhynochosporeae).

Table 2. Average number of deep purple flavonoids occurring in the tribes of Cyperaceae.

Hypolytreae	2.2
Sclerieae	3.6
Lagenocarpeae	3.7
Cypereae	4.7
Cariceae	4.8
Rhynchosporeae*	5.0
Scirpeae	5.4
Dulichieae	8.0

*Excl. *Carpha alpina*

In the remaining tribes the average number of deep purple compounds was found to be considerably smaller (Table 2). The tribe Hypolytreae is especially notable in this respect, because in *Diplasia karataefolia*, *Mapania macrophylla* and *M. sylvatica* no compounds were found. *Paramapania* seems to be devoid of all flavonoids; and in *Scirpodendron ghaeri* a single deep purple compound was observed. In Sclerieae, in the species *Bequerelia cymosa* and *Bisboeckelera irrigua*, and in Lagenocarpeae, in *Trilepis lhotzkiana*, no compounds were found. In Cariceae, as in Cypereae, the deep purple compounds are more numerous than in the two last-named tribes, but less so than in Scirpeae and Rhynchosporeae, on average.

Eriophorum angustifolium (Scirpeae) and *Carex baccans* (Cariceae) are notable, because they seem to represent exceptions in their respective genera, having no flavonoid compounds at all (also *Paramapania* above). In the other genera, even if no deep purple compounds were found, at least other flavonoids were observed. This suggests that in these two cases the capacity to synthesize flavonoids has been lost relatively recently.

The trend observed in the occurrence of the compounds is best seen from Table 2, showing the average number in each tribe. It appears that the deep

purple flavonoids tend to be more numerous in tribes where bisexual flowers occur; on the other hand, a small number or even lack of compounds is recorded in several genera of the tribes with unisexual flowers.

Pattern of compounds on chromatograms

In Figs. 1—5 the chromatograms of the species of each tribe are united. In these scatter diagrams the position of the spots is expressed with R_f values, giving them an ordinary mathematical significance. This results in a specific pattern of distribution on the chromatograms.

The pattern of compounds is best seen in the tribe Cariceae (Fig. 5), where the compounds are mainly concentrated in five distinct regions. One of these is near the lower right corner (R_f values about 0.67; 0.04); the

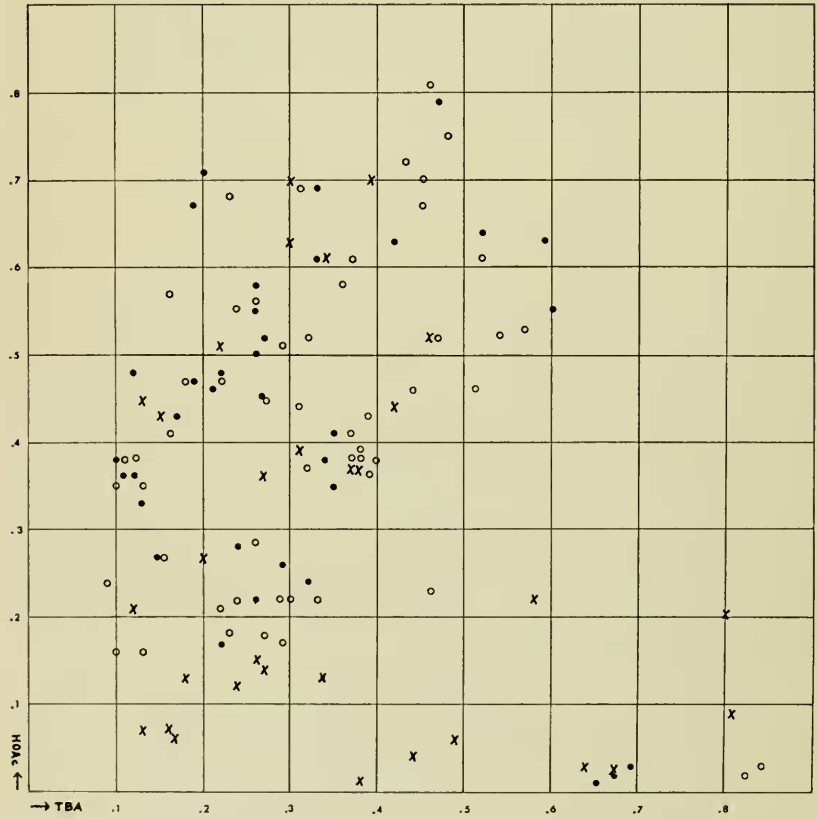

Fig. 1. Pattern of flavonoids occurring in members of the tribes Hypolytreae (•), Lagenocarpeae (x) and Sclerieae (o).

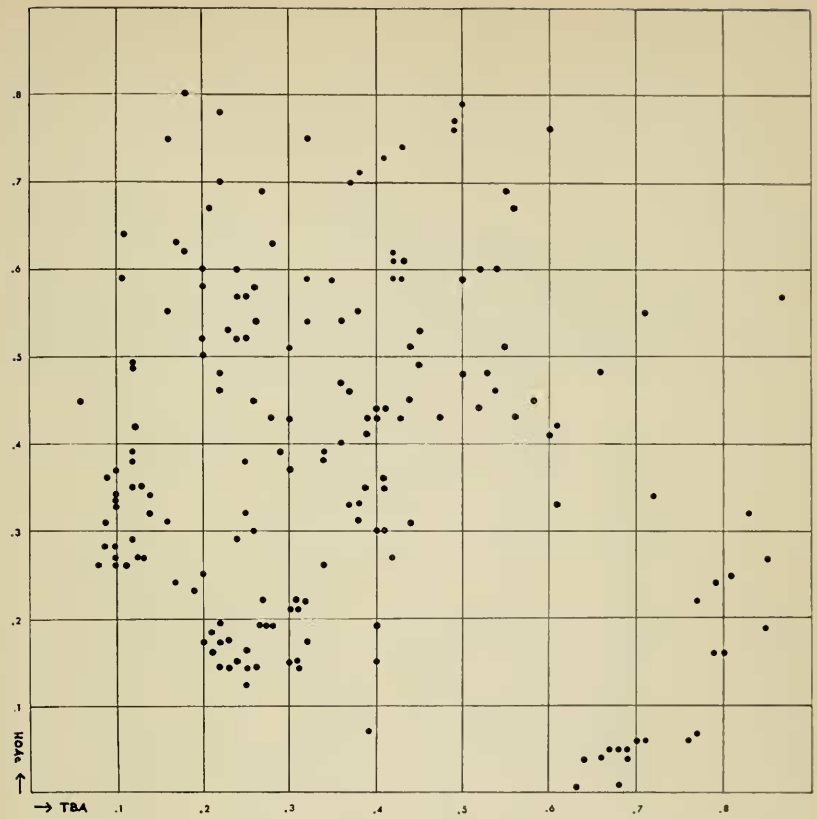

Fig. 2. Pattern of flavonoids occurring in members of the tribe Scirpeae.

compounds in this region are thus very soluble in TBA, but almost insoluble in HOAc. They are most likely aglycones (see MABRY et al. 1970:11). Most of the other compounds are concentrated in four separate regions in the lower left quarter of the diagram. These are, no doubt, mainly monoglycosides.

The pattern, although less pronounced, is repeated in all the other diagrams; however, the concentration into the five separate regions is far less obvious. Characteristic features may be found in all of them.

The tribes Hypolytrea, Lagenocarpeae and Sclerieae are shown together (Fig. 1). This is because the tribes were not very well represented in the material (Table 1), and, on the other hand, the number of compounds recorded in them was also small. However, the tribe Lagenocarpeae is notable

for containing a series of compounds soluble in TBA to various degrees and poorly soluble in HOAc. Further, hardly any compounds with R_f values of about 0.10; 0.20—0.40 were detected in Lagenocarpeae in comparison with the other two tribes. The small number of aglycones is characteristic of all three tribes: none was recorded in Sclerieae in the region mentioned as typical for Cariceae (Fig. 5) and only a few in the other two tribes. An interesting concentration of spots was found in the region with R_f values of about 0.38; 0.38 in Sclerieae. A very strong concentration in the same region was found in the tribe Rhynchosporeae (Fig. 3); however, the spectral data show that the compounds are not identical.

The diagram of the tribe Scirpeae also includes the data of the tribe Dulichieae (Fig. 2). In the lower half of the diagram three of the regions of concentration typical of the Cariceae diagram (Fig. 5) may be recognized.

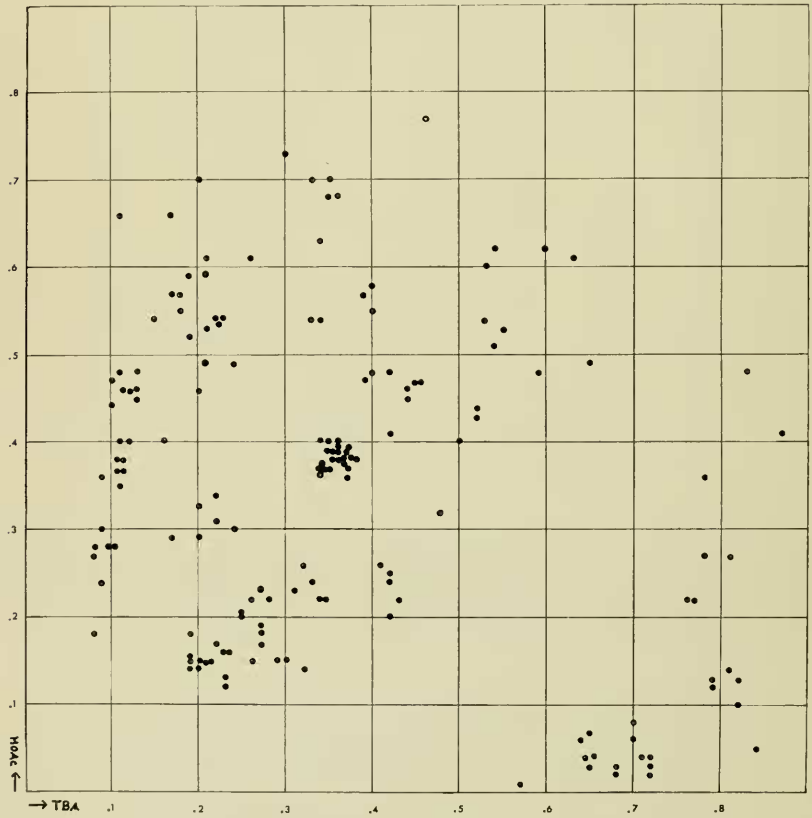

Fig. 3. Pattern of flavonoids occurring in members of the tribe Rhynchosporeae.

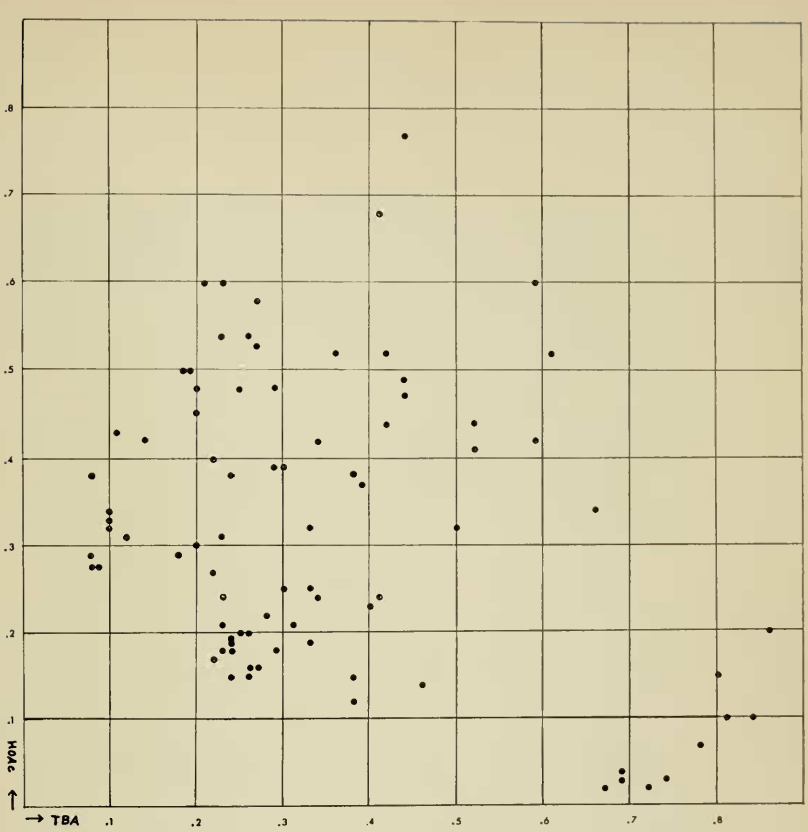

Fig. 4. Pattern of flavonoids occurring in members of the tribe Cypereae.

In the central parts of the diagram numerous compounds occur and hardly any concentration can be observed. Obviously the large number of compounds would give taxonomic criteria useful at the species level. The tribe Scirpeae is characterized, for example, by some compounds which give spots occuring in the area with R_f values of 0.39; 0.34 or 0.40; 0.43.

In the lower half of the diagram of the tribe Rhynchosporeae the same general pattern observed in Fig. 5 may be traced. However, Rhynchosporeae differs from all other tribes in having an exceptionally compact group of spots near the centre of the diagram (R_f values about 0.37; 0.38). This is believed to represent a single compound. It occurs in 14 of the 34 genera of Rhynchosporeae included in this study; so far it has not been recorded outside this tribe. A number of other compounds common to several mem-

bers of the tribe separate it from Cariceae, for example; a chain of compounds near the left margin of the diagram is notable.

Because the tribe Cypereae is held by some to consist of a single large genus, it might be expected that the pattern of compounds would show a compact structure such as is found in the diagram for Cariceae (Fig. 4). However, this is not the case. Basically, the diagram greatly resembles that of Scirpeae; the concentration is probably even less pronounced. Lack of concentration may be partly caused by the small number of samples. However, characteristic features do exist. For example, in the R_f region of about 0.40; 0.40, near the central parts of the diagram, only a few compounds occur; in all other tribes this region is more densely occupied.

It may be concluded that the pattern of the compounds studied displays

Fig. 5. Pattern of flavonoids occurring in members of the tribe Cariceae.

a large number of features which are to varying extents characteristic of each of the tribes of Cyperaceae. Of course, an attempt to assign a solitary specimen to its tribe on the basis of this pattern alone may present difficulties.

Some chemical features

The analytical results obtained pose several chemical problems concerning the structures of the compounds included in this study. This is not the place to examine these problems in detail, but certain general aspects must be discussed, and the most important classes of the flavonoids studied must be indicated.

C-glycosides. In the overwhelming majority of cases hydrolysis gave no result at all, whether the reagent used was β-glucosidase or weak hydrochloric. acid. Thus the majority of compounds studied are C-glycosides. Most of them are derivatives of apigenin and luteolin, and, for example, no free 3-hydroxyl groups were observed. The identity of the sugar moiety was not established; however, there is some evidence suggesting that, at least in several cases, it is not glucose. It is estimated that the material analysed included at least 50 C-glycosides.

O-glycosides. In the material very few O-glycosides were detected. In addition, these were found only in the tribes Scirpeae (excl. *Dulichium*) and Cariceae. In Cariceae a single compound was found in *Carex planostachys.* In Scirpeae several compounds were detected, viz. three in *Scirpus tabernaemontani,* two in *Fuirena simplex* and one in *Fimbristylis* sp. *Scirpus* and *Fuirena* may have one of these compounds in common.

The presence of O-glycosides is deduced from the results of the acid hydrolysis test. In addition to complete cleaving off of the sugar part, the acid treatment frequently produced a small change in the solubilities (R_f values) of the compound. Also the test often resulted in C-glycosyl flavonoid mixtures (see Mabry et al. 1970:24—25).

In contrast to acid hydrolysis, enzymatic treatment never produced indisputably positive results. It may therefore be concluded that O-glycosides occur within the tribes Scirpeae and Cariceae, but the identity of the sugar part is unknown; possibly it is not glucose.

Rhynchosporeae

As was pointed out above in the diagram for Rhynchosporeae (Fig. 3), there occurs a region with an unusual frequency of spots, with R_f values of about 0.37; 0.38. In fact, 21 species belonging to 14 genera were found to possess this compound. It is believed to be the same substance in all of them, although spectral data, for example, are only available for two, namely *Cladium jamaicense* and *Rhynchospora alba.* The species are:

Caustis flexuosa
Cladium californicus
C. chinense
C. jamaicense
C. mariscus
Costularia natalensis
Cyathochaeta diandra
Dichromena ciliata
D. colorata
Gahnia aspera
Gymnoschoenus sphaerocephalus
Oreobolus obtusangulatus
Pleurostachys gaudichaudii
Psilocarya nitens
Rhynchospora alba
R. caduca
R. cephalotes
R. corniculata
Schoenus ferrugineus
Tetraria circinalis
Tricostularia undulata

The analytical results found in the two species are almost identical, possibly the largest difference being found in the R_f values: 0.36; 0.39 *(Cladium)* and 0.38; 0.38 *(Rhynchospora)*. The colour in transmitted UV light was invariably found to be deep purple, which in NH_3 fumes turned yellow-green. Enzymatic hydrolysis produced no change; but acid hydrolysis resulted in two spots, thus indicating the presence of a mixture of C-glycosides after the treatment. One of the spots occupied the original position, the new one being less soluble in both TBA and HOAc. Finally the spectral data are as follows (in *Rhynchospora alba*):

MeOH	209, 256, 269, 346
NaOMe	236 (sh), 268, 333 (sh), 406
$AlCl_3$	211, 234 (sh), 274, 301 (sh), 330, 426
HCl	210, 232 (sh), 264 (sh), 276, 295 (sh), 360, 383
NaOAc	259, 276 (sh), 325 (sh), 383
H_3BO_3	263, 374, 432 (sh)

The compound isolated from *Cladium* gave almost exactly the same spectrum.

These analytical data are close to those given by Mabry et al. (1970:98) for iso-orientin. However, the R_f values as well as the maxima of the spectrum in NaOAc differ significantly.

DISCUSSION

Although the chemical identity of the deep purple flavonoids is not yet completely established and accordingly some affinities are sure to have been overlooked the preliminary observations presented above seem to justify some concluding remarks.

First, it is worth while paying attention to the trend in the number of deep purple compounds and the occurrence of O-glycosides within the family. As Table 2 shows, the compounds tend to be more numerous in tribes where bisexual flowers occur, e. g. Scirpeae. Although generally rare, the O-glycosides were specifically discovered in the same tribe, Scirpeae. One of the O-glycosides was isolated from a member of the tribe Cariceae, in which the number of deep purple compounds is not especially small, although the

flowers are unisexual. This is possibly a fact which deserves more consideration in the future.

In the pattern of the compounds studied, the tribe Cariceae seems to be the most coherent one in the family. In this tribe, the coherence corresponds with the morphological features. In every other group the pattern of the compounds is less coherent, suggesting that affinities within each of these tribes may be more remote. However, an interesting exception is the compound found exclusively within the Rhynchosporeae, but which seems to be present in a number of genera.

Harborne (1967:313) has discussed the primitive and advanced characters found in the flavonoid composition of plants in general. As one might expect, a mixture of these characters is found in Cyperaceae, and the application needs caution. However, it is interesting to note that the presence of a large number of C-glycosides may be taken as a primitive character, while increasing diversification of compounds as well as the presence of O-glycosides are probably advanced characters.

Finally, it may be concluded that analysis of the flavonoid composition seems to provide an additional, powerful tool in the search for taxonomic affinities within the family Cyperaceae.

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Table 1. List of specimens studied arranged according to tribes. Specimens of which a variety of analytical data ware available *in italics*. Number of compounds recorded in each specimen is given in the column in the middle.

Hypolytreae

Chorisandra enodis Nees	4	S. Australia. French (s. n.)	(US)
Chrysithrix capensis L.	4	S. Africa. Schlechter (1916)	(US)
Diplasia karataefolia L. C. Rich.	0	Surinam. Irwin & al. (55551)	(US)
Hypolytrum heterophyllum Boeck.	2	Liberia. Baldwin (11047)	(US)
H. nemoreum (Vahl) Spreng.	2	Sumatra. Bartlett (6753)	(US)
H. silvaticum Kunth	5	Br. Guiana. Irwin (1139)	(TEX)
H. silvaticum Kunth (= H. nicaraguense Liebm.)	1	Guatemala. Tuerckheim (1193)	(US)
Lepironia articulata (Retz.) Domin	5	N. S. Wales. Constable (19382)	(US)
Mapania africana Boeck.	2	Liberia. Cook (80)	(US)
M. cuspidata (Miq.) Uitt.	2	Borneo. Jacobs (5004)	(US)
M. macrocephala (Boeck.) Pfeiffer	0	Brazil. Irwin & al. (47525)	(US)
M. sylvatica Aubl.	0	Br. Guiana. Maguire & Fanshawe (22831)	(US)
Paramapania radians (Clarke) Uitt.	0	Borneo. Jacobs (5597)	(US)
Scirpodendron ghaeri (Gaertn.) Merril	1	Moluccas. Robinson (Pl. Rumph. Amb. 437)	(US)
Thoracostachyum bancanum (Miq.) Kurz	4	Malaya. Md. Nur (34069)	(US)

Dulichieae

Dulichium arundinaceum (L.) Britt.	7	Mass., Brown (s. n.)	(TEX)
D. arundinaceum (L.) Britt	9	Maine. Ogden (2486) & Steinmetz	(US)

Scirpeae

Abilgaardia monostachya (L.) Vahl	6	Florida. Killip (44490)	(US)
Ascolepis brasiliensis Clarke	3	Brazil. Mexia (5839)	(US)
A. capensis Benth.	6	Nyasaland. Buchanan (s. n.)	(US)
Bulbostylis capillaris (L.) Clarke	3	Texas. Kukkonen (1511)	(H)
B. cardicarpa (Ridl.) Clarke	3	Kenya. Maas Geesteranus	(US)
B. paradoxa (Spreng.) Clarke	3	Brazil. Dawson (14496)	(US)
Crosslandia setifolia Fitzg.	11	N. T., Australia. Mukee (8443)	(US)

Eleocharis acicularis (L.) Roem & Schult.	5	Alberta. Moodie (1143)	(US)
E. montevidensis Kunth (18)	5	Texas. Kukkonen	(H)
E. montevidensis Kunth (25)	9	Texas. Kukkonen	(H)
E. palustris (L.) R. Br.	7	Sweden. Alm (2770)	(US)
Eriophorum angustifolium Honck.	0	Alaska. Bormann et al. (135)	(US)
E. comosum Wall.	3	China. Henry (9587)	(US)
E. spissum Fern	6	Labrador. Senn (3382)	(US)
Ficinia bracteata Boeck.	1	S. Africa. Hafström & Linde-berg (s. n.)	(US)
Fimbristylis dichotoma (L.) Vahl	5	Ryukyu Isl. Fosberg (37716)	(US)
F. obtusifolia (Lam.) Kunth	2	Liberia. Baldwin (5968)	(US)
F. vahlii (Lam.) Link	2	Ark. Demaree (14072)	(US)
F. spadicea Vahl	12	Texas. Eifert (s. n.)	(H)
Fuirena scirpoidea Michx.	5	Miss. Demaree (30699)	(US)
F. simplex Vahl	6	Texas. Kukkonen	(H)
F. umbellata Rottb.	6	Ryukyu Is. Fosberg (37832)	(US)
Hemicarpha micrantha (Vahl) Britton	2	Mo. Bush (336)	(US)
Hemichlaena angustifolia Schrad.	4	S. Africa. Schlechter (996)	(US)
Lipocapha argentea R. Br.	2	Sumatra. Toroes (3912)	(US)
L. sellowiana Kunth	3	Argentina. Pedersen (184)	(US)
Scirpus atrovirens Willd.	8	Iowa. Fay (4036)	(US)
		Alaska. Spetzman (981)	(US)
S. californicus (C. A. Mey.) Steud.	2	Texas. Kukkonen (1504)	(H)
S. maritimus L.	6	Belgium. Stockmans (s. n.)	(US)
S. silvaticus L.	5	Finland. Heikkinen (s. n.)	(US)
S. tabernaemontani Gmel.	5	Finland. Kukkonen (1485)	(H)
Trachystylis foliosa Blake	2	Queensland. Clemens (44273)	(US)
Websteria submersa (Sauv.) Britton	1	Trinidad. Richardson (2023)	(US)

Rhynchosporeae

Arthrostylis aphylla R. Br.	2	Australia. Specht (1069)	(US)
Carpha alpina R. Br.	(1)	N. Z. Walker (4351)	(US)
C. paniculata Ph.	3	Chile. Eyerdam (10567)	(US)
Caustis flexuosa R. Br.	7	N. S. Wales. Eames (s. n.)	(US)
Cladium californicus Wats.	6	Ariz. Clover (4292)	(US)
C. chinense Nees	5	Ryukyu Is. Fosberg (37231 a)	(US)
C. jamaicense Cranz	9	Texas. Kukkonen	(H)
C. mariscus (L.) R. Br.	9	Pl. Pol. Exs. 492. Madalski	(US)
C. restioides (Sw.) Benth.	10	Guadeloupe. Webster (9121)	(US)
Costularia natalensis Clarke	5	Nyasaland. Brass (16740)	(US)
Cyathochaete diandra Nees	4	N. S. Wales. Booman (s. n.)	(US)
Dichromena ciliata Vahl	4	Equador. Camp (E-3792)	(US)
D. colorata (L.) A. S. Hitchc.	3	Florida. Killip (42344)	(US)
Evandra aristata R. Br.	7	W. Australia. Eames & Hotchiss (s. n.)	(US)

Gahnia aspera (R. Br.) Spreng.	5	N. S. Wales. Constable (17831) & Chippendale	(US)
G. beecheyi Mann.	5	Hawaii. Meebold (8631)	(US)
Gymnoschoenus sphaerocephalus (R. Br.) Hook. f.	3	N. S. Wales. Betche (22502)	(US)
Lepidosperma concava R. Br.	6	N. S. Wales. Mair (5246)	(US)
Oreobolus furcatus Mann.	3	Hawaii. Degener & al. (12559)	(US)
O. obtusangulatus Gaud.	2	Chile. Eyerdam (10595)	(US)
Pleurostachys boliviana Palla	2	Bolivia. Buchtien (1233)	(US)
P. gaudichaudii Brogn.	1	Brazil. Smith & Klein (7544)	(US)
Psilocarya nitens (Vahl) Wood.	7	Florida. Standley (322)	(US)
Rhynchospora alba (L.) Vahl	8	Finland. Kukkonen	(H)
R. caduca Ell.	6	Texas. Cory (51079)	(US)
R. cephalotes (L.) Vahl	5	Panama. Standley (26375)	(US)
R. corniculata (Lam.) Gray	6	Philippines. Santos (6001)	(US)
R. corymbosa (L.) Britt.	2	Czechoslovakia. Deyl (s. n.)	(US)
Schoenus ferrugineus L.	7	S. Carolina. Alexander (55)	(US)
S. nigricans L.	2	Florida. Brass (15924)	(US)
S. rigens Blake	4	W. Australia. Fitzgerald (23750)	(US)
Tetraria circinalis Clarke	8	S. Africa. Keet (994)	(US)
T. thouarsii Beauv.	4	S. Africa. Schlechter (7512)	(US)
Tricostularia undulata (T. W.) Kern	5	Borneo. Jacobs (5490)	(US)

Cypereae

Androtrichum trigynum (Spreng.) Pfeiffer	0	Brazil. Reitz (5896)	(US)
Courtoisia cyperoides Kuntii	3	Madagascar. Hildebrandt (3795)	(US)
Cyperus articulatus L.	3	Texas. Rose & Russell (24239)	(US)
C. javanicus Houtt.	4	Philippines. Merrill (428)	(US)
C. rotundus L. (22)	6	Texas. Kukkonen	(H)
C. rotundus L. (33 A)	3	Texas. Kukkonen	(H)
C. sp. (15)	6	Texas. Kukkonen	(H)
C. sp. (16)	4	Texas. Kukkonen	(H)
C. hermafroditus Standl. (17)	7	Texas. Kukkonen	(H)
C. sp. (26)	3	Texas. Kukkonen	(H)
C. sp. (27)	6	Texas. Kukkonen	(H)
C. sp. (28)	7	Texas. Kukkonen	(H)
C. sp. (29)	5	Texas. Kukkonen	(H)
C. sp. (30)	8	Texas. Kukkonen	(H)
C. difformis L. (34)	7	Texas. Kukkonen	(H)
Kyllinga brevifolia Rottb.	4	Peru. Asplund (12775)	(US)
K. flava Clarke	4	Uganda. Dümmer (2676)	(US)
Remirea maritima Aubl.	4	Santo Domingo. Ekman (12225)	(US)

Sclericeae

Becquerelia cymosa Brogn.	0	Venezueala. Pittier (14131)	(US)
Bisboechelera irrigua (Nees) Kuntze	0	Br. Guiana. Smith (2785)	(US)
B. microcephala (Boeck) Koyama	0	Br. Guiana. Maguire (32115)	(US)
Calyptrocarya glomerulatach (Brogn.) Urban	1	Br. Guiana. Maguire & al. (46078 A)	(US)
Diplacrum aricinum R. Br.	3	Japan. Ohwi & Koyama (962)	(US)
D. notopterum Clarke	3	Venezuela. Williams (14915)	(US1
Eriospora abyssinica A. Rich.	4	Eritrea. Pappi (1269)	(US)
Pteroscleria longifolia Griseb.	3	Trinidad. Britton & al. (2000)	(US)
Scleria bancana Miq.	4	Sumatra. Toroes (3091)	(US)
S. bulbifera A. Rich.	6	Tanganyika. Schlieben (3463)	(US)
S. ciliata Michx. (21)	5	Texas. Kukkonen	(H)
S. ciliata Michx. (32)	13	Texas. Kukkonen	(H)
S. macrophylla Presl	6	Venezuela. Tamayo (4040)	(US)
S. verrucosa Willd.	3	Liberia. Baldwin (11052)	(US)

Lagenocarpeae

Cephalocarpus rigidus Gilly	4	Venezuela. Maguire (33632)	(US)
Cryptangium insigne Boeck.	2	Brazil. Glaziou (20061,	(US)
Didymiandrum stellatum (Boeck.) Gilly	3	Br. Guiana. Maguire & Fanshawe (32294)	(US)
Everardia montana Ridley	4	Venezuela. Maguire & al. (37209)	(US)
Exochogyne amazonica Clarke	4	Suriname. Maguire & al. (54215)	(US)
Lagenocarpus glomerulatus Gilly	4	Br. Guina. Maguire & Maguire (45916)	(US)
L. rigidus (Kunth) Nees	5	Br. Guiana. Maguire & Fanshawe (32549)	(US)
Microdracoides squamosus Hua	7	Cameroons. Bücher (s. n.)	(B)
Trilepis lhotzkiana Nees	0	Brazil. Smith & al. (6443)	(US)

Cariceae

Carex baccans Nees	0	Thailand. Rock (1574)	(US)
C. bicknellii Britt.	8	Texas. Kukkonen	(H)
C. capitata Sol.	5	Finland. Laine (s. n.)	(H)
C. chordorrhiza Ehrh.	4	Finland. Kukkonen (1490)	(H)
C. cruciata Wahlenb.	6	Thailand. Smith (661)	(US)
C. distachya Desf.	3	Italy. Guadagno (s. n.)	(US)
C. echinata Murr. (4)	4	Finland. Kukkonen	(H)
C. echinata Murr. (8)	4	Finland. Kukkonen	(H)
C. emoryi Dewey	8	Texas. Kukkonen (1518)	(H)
C. filifolia Nutt.	2	N. Dakota. Stevens (s. n.)	(US)

C. geyeri Boott	4	Wash. Hermann (18993)	(US)
C. *globularis* L.	5	Finland. Kukkonen	(H)
C. *magellanica* Lam.	7	Finland. Kukkonen	(H)
C. *media* R. Br.	5	Finland. Laine (s. n.)	(H)
C. *microdonta* Torr. & Hook.	9	Texas. Kukkonen	(H)
C. *microrhyncha* Mack.	10	Texas. Kukkonen	(H)
C. *nardina* Fr.	5	B. C. Beamish & Vrugtman (60968)	(US)
C. *nigra* (L.) Reich. (1)	4	Finland. Kukkonen	(H)
C. *nigra* (L.) Reich. (3)	6	Finland. Kukkonen	(H)
C. *pauciflora* Lightf.	7	Finland. Kukkonen	(H)
C. *planostachys* Kunze	7	Texas. Kukkonen	(H)
C. rariflora (Wahlenb.) Sm.	7	Norway. Laine (s. n.)	(H)
C. *rostrata* Stokes	5	Finland. Kukkonen	(H)
C. schiedeana Kunze	5	Mexico. Pringle (11319)	(US)
Kobresia hyperborea Pors.	3	Alaska. Cantlon & Malcolm (58.0040)	(US)
K. laxa Boeck.	3	Kashmir. Stewart (5692a)	(US)
K. myosuroides (Vill.) F. & Paol.	2	Alberta. Hermann (13460)	(US)
K. nitens Clarke	5	Kashmir. Stewart (22072)	(US)
K. royleana (Nees) Boeck.	3	Kashmir. Koelz (2685)	(US)
K. schoenoides (C. A. May.) Steud.	5	Kashmir. Koelz (5829)	(US)
K. simpliciuscula (Wahlenb.) Mack.	3	Yukon. Porsild & Breitung (9877)	(US)
Schoenoxiphium lehmanii (Nees) Steud.	2	Kenya. Maas Geesteranus (5159)	(US)
Uncinia hamata (Sw.) Urban	1	Guatemala. Steyermark (s. n.)	(US)
U. uncinata (L. f.) Kük.	5	Hawaii. St. John (10240)	(US)